

## 1 Titanium Molybdenum Alloy Guidewires

3 Inventors: Stephen Nuss

## 5 Background of the Invention

## 7 Field of the Invention

9 This invention relates to the field of medical devices and more particularly to  
10 guidewires for use primarily in intra vascular procedures. Guidewires made with a  
11 titanium molybdenum alloy allow for a flexible and formable tip with reduced kinking,  
12 high torque, trackability and high column strength.

## 14 Description of the Related Art

15  
16 *Dr. Nuss* A major requirement for guidewires and other guiding members, whether they be  
17 solid wire or tubular members, is that they have sufficient column strength to be pushed  
18 through a passageways in a patient such as the patient's vascular system with minimal  
19 kinking or binding. However, the distal section of the guidewire must be flexible enough  
20 to avoid damaging the blood vessel or other body lumen through which it is advanced.  
21 Efforts have been made to improve both the strength and flexibility of guidewires to  
22 make them more suitable for their intended uses, but strength for pushing and flexibility  
23 for turning without damaging vascular walls tend to be diametrically opposed to one

1 another, in that an increase in one usually involves a decrease in the other. There has been  
2 a gradual decrease in the profiles or transverse dimensions of commercially available  
3 intravascular catheters and guidewires particularly for use in coronary arteries. However,  
4 concomitant with the decrease in profile has been a loss in pushability and kink  
5 resistance.

6 The distal portion of the guidewires frequently have a spring or coil around a  
7 tapered, thinner and therefore softer metal core. The thinner softer core may be too thin to  
8 engage the coil and may therefore allow the coil to kink when bent.

9 Guidewires have been made of many different materials. The most popular  
10 materials are stainless steel and NiTi alloys such as Nitinol.

11 Stainless steel guidewires tend to kink. They have good pushability but are not  
12 flexible enough to easily bend inside of the vascular system. Stainless steel has good  
13 torque qualities for rotating the guidewire but tends to bind when rotated since it does not  
14 readily flex. Once the guidewire is kinked, it must be discarded and replaced with a new  
15 guidewire.

16 Jms 92 NiTi guidewires tend to be too springy, especially when negotiating a tortuous  
17 path in vessels, they do not have good pushability because want to straighten out or return  
18 to their original shape. NiTi guidewires will readily get hung up when rotated while  
19 extending around a curved path. NiTi guidewires can not be torqued as readily as  
20 stainless steel because it is more springy. NiTi guidewires tend to have good shape  
21 memory. The shape memory makes it difficult for a physician. to shape the tip of the  
22 guidewire with his fingers for accessing difficult to reach portions of the patient's  
23 vascular system.

1 The guidewires need to have distal ends that are soft for bending and turning  
2 inside of the blood vessels as they are advanced and so they will not puncture the vessel  
3 walls.

4 The most popular guidewires are made out of stainless steel or NiTi alloys. Both  
5 of these materials have advantages and drawbacks. A different guidewire material is  
6 required to have the desirable qualities of both without as many drawbacks to enhance the  
7 performance of guidewires.

#### 8 9 Summary of the Invention

10  
11 A titanium molybdenum alloy used to make guidewires for use in passages within  
12 a body has several advantages over NiTi and stainless steel guidewires. The titanium  
13 molybdenum alloy has properties of high springback, and flexibility that is, in between  
14 the values of stainless steel and NiTi alloys which are the two most widely used metals  
15 used for making guidewires.

16 The titanium molybdenum alloy has moderate stiffness, about 42% of stainless  
17 steel and excellent torque transmission and formability. It is softer and more flexible than  
18 stainless steel for better bendability while negotiating though passageways in the body  
19 and less likely to puncture the walls of the passageways. The titanium molybdenum alloy  
20 is also easier to torque than stainless steel, which tends to bind when the guidewire is in  
21 nonlinear passageways. The titanium molybdenum alloy is stronger and has a better  
22 pushability than NiTi alloys and is easier to torque because it is less springy and will not

1 bind against the walls of a vessel as much on a non linear path allowing easier rotation of  
2 the guidewire.

3 Titanium molybdenum alloys can be easily welded or soldered using standard  
4 manufacturing techniques, as opposed to NiTi alloys which are not easy to weld or  
5 solder.

6 The titanium molybdenum alloy can be tapered in steps at the distal end  
7 producing a softness gradient with the distal end the softest. This allows the distal tip to  
8 be more flexible and bend around curves without puncturing the tissue in the passageway.  
9 The titanium molybdenum alloy core is softer so it can be make thicker such that a coil  
10 around the core engages at a larger diameter and will not kink as it bends.

11 The titanium molybdenum alloy guidewire can be coated with a plastic such as  
12 Teflon ® or a hydrophilic coating to make it slipperier.

13 The titanium molybdenum alloy is preferably a mixture of about 78% titanium  
14 11.5% molybdenum 6% ~~zinc~~ <sup>zirconium</sup> and 4.5% tin by weight.

15  
16 Objects of the Invention

17  
18 It is an object of the invention to provide a guidewire with the right amount of  
19 stiffness to easily advance the guidewire.

20 It is an object of the invention to provide a guidewire with the right amount of  
21 softness to bend around curves in a passageway without puncturing the walls of the  
22 passageway.

1 It is an object of the invention to provide a guidewire with rotatability such that it  
2 can be torqued without binding up in a nonlinear passageway.

3 It is an object of the invention to provide a guidewire with a coil at the distal end  
4 of the guidewire which is less likely to kink when bent.

5 It is an object of the invention to provide a guidewire with a softness gradient at  
6 its distal end.

7 It is an object of the invention to provide a guidewire which steers better in the  
8 passageways of the patient.

9 It is an object of the invention to provide a guidewire which is easily weldable  
10 and solderable.

11 It is an object of the invention to provide a guidewire with an easily shaped tip.

12 It is an object of the invention to provide a guidewire with a radio opaque tip.

13 It is an object of the invention to provide a guidewire having a higher kink  
14 resistance than a stainless steel guidewire.

15 It is an object of the invention to provide a guidewire having less springiness than  
16 a NiTi alloy guidewire.

17 It is an object of the invention to provide a guidewire having a coating to make is  
18 easier to advance the guidewire through the vascular system of the patient.

19 Other objects, advantages and novel features of the present invention will become  
20 apparent from the following detailed description of the invention when considered in  
21 conjunction with the accompanying drawing.

22

## Brief Description of the Drawings

Fig. 1 is a side view of the guidewire.

Fig. 2 is a graph comparing stress strain curves for NiTi alloy, stainless steel and TiMo alloy.

## Description of the Preferred Embodiments

Guidewires used in passageways within patients are used for a large number of medical procedures. Many of the procedures involve the use of the guide as a guidewire for inserting catheters and other devices in the vascular system of the patient. Guidewires have been made from stainless steel, which is stiff and does not readily bend around in the passageways of the patient. Guidewires are also frequently made using a NiTi alloy which is softer and springier than stainless steel and has a better memory but is not as stiff so that it does not have the pushability of stainless steel. Further NiTi alloy is not as easily bendable so that the distal tip can not be as readily shaped.

2043 A guidewire is shown in Fig. 1 having a titanium molybdenum alloy which has properties between that of stainless steel and NiTi alloys. The titanium molybdenum alloy is easier to use and has better rotatability, softness and pushability for use in the passageways of patients than guidewires made of other materials.

The guidewire in Fig. 1 is made from a titanium molybdenum alloy comprising about 78% titanium, 11.5% molybdenum 6% zirconium and 4.5% tin by weight. The stiffness is about 42% that of stainless steel. o/c

1 Alternatively the guidewires can be made with a range of values for its alloys.

*Ins 4*  
2 The range of values is approximately 75-83% titanium, 8-14% molybdenum 4-8%  
3 zirconium and 2-6% tin by weight

4 The titanium molybdenum alloy can be deflected more than 42% more than  
5 stainless steel with no permanent deformation and has a lower force deflection rate and a  
6 higher spring back and flexibility.

7 Comparing stainless steel to Nitinol, which is a NiTi alloy, stainless steel takes a  
8 set which is not a desirable quality for a guidewire and, Nitinol is too springy which is  
9 not a desirable quality for a guidewire. If a guidewire is too stiff it takes a set and will not  
10 easily bend. The stiffness however makes for good pushability allowing for the guidewire  
11 to be inserted into a passageway and allows the guidewire to be rotated at the distal end  
12 when turned at the proximal end. However if the guidewire does not bend easily and  
13 there is a nonlinear passageway that the guidewire must negotiate, the stiffness of the  
14 guidewire will form arches in the guidewire around curves and will not torque as easily  
15 since the entire guidewire will tend to push against the wall of the passage. If the  
16 guidewire is too springy and the guidewire is torqued the guidewire will bind in the  
17 curved portions in the passageways.

*Ins 45*  
18 A guidewire made from a titanium molybdenum alloy is less springy than NiTi  
19 alloys and but more springy than stainless steel. Titanium molybdenum alloys are stiffer  
20 than NiTi alloys and but not as stiff as stainless steel. Therefore titanium molybdenum  
21 alloys have desirable properties when used in guidewires.

*Ins 46*  
22 Figure 2 shows the relative stress and strain curves comparing NiTi alloys, curve  
23 35, stainless steel, curve 30 and titanium molybdenum alloy, curve 33 guidewires. The

graph charts the percentage of maximum bending moment (inch=pounds) as related to the angular deflection (degrees). It shows the percentage that each wire returns to it's original shape after being bent to a given moment. As shown on the chart, when deflected, Nitinol returns to it's shape, stainless steel returns to only about 5% of it's original shape and titanium molybdenum alloy such as Beta III alloy returns to about 50% of its original shape. Thus the titanium molybdenum alloy such as Beta III alloy exhibits springback properties between Nitinol and Stainless staeel.

*Insert* Fig. 1 shows a side view of a guidewire 10 having a proximal end 12 and a distal end 14. The distal end 14 has a smaller diameter than the proximal end 12 to make is softer and more easily bendable. It is desirable to have a softer distal end 14 such that the guidewire will bend and follow the curves of a blood vessel or other passageway that the guidewire is inserted into. The guidewire is provided with a rounded distal tip 16 at the tip of the distal end 15 to secure the coil 18 to the distal end 14 and to prevent the tip of the distal end 15 from poking thought tissue in the passageway as the guidewire is being inserted. The guidewire 10 is also provided with a coil 18 which can be made out of platinum, tungsten or similar materials to act as a spring, allowing the thinned distal end 14 to bend and yet spring back into place after the guidewire is transported around a curve in the passageway.

In the past coils 18 would tend to kink and not return to their original shape if there was a large space between the inside diameter of coil 18 and the core of the distal end 14 of the guidewire 10. The titanium molybdenum alloy has a softness which allows it to have a larger diameter and still be soft enough at the distal end 14 such that the outside diameter of the distal end of the guidewire 10 engages the coil 18 on the inside



1 diameter reducing the space therebetween and prevents the coil from kinking as the coil  
2 18 and the distal end 14 bend. The coil 18 is wound around the core of the distal end 14  
3 without spaces between the turns and in tight contact with core to prevent kinks from  
4 occurring when the guidewire is bent.

5 The titanium molybdenum alloy is made softer by tapering the distal end 14 to  
6 reduce the cross section of the guidewire. The tapering at the distal end 14 provides a  
7 gradient of softness with the tip of the distal end 15 being the softest. The gradient of  
8 softness helps the tip bend while keeping the remainder of the guidewire 10 straighter.  
9 The distal end 14 can have a tapered portion 20 which gradually changes the diameter of  
10 the guidewire material and provides for a gradient of softness.

11 *Ins 98* Abrupt changes in the stiffness of the distal end of the guidewire causes kinking at  
12 stress points of the coil, when the distal end is bent. By having a larger number of tapered  
13 sections with small changes in the diameter the flexibility (bendability) of the guidewire  
14 can continually increase toward the distal end of the guidewire 14 without an abrupt  
15 change averting kinking

16 The proximal end 12 of the guidewire is less flexible and is more uniform and can  
17 transmit torque and pushing force with high fidelity.

18 *Ins 99* The titanium molybdenum alloy steers better than stainless steel guidewires or  
19 NiTi alloy guidewires because it is more flexible than stainless steel yet stiff enough to  
20 have torque and it stiffer than NiTi.

21 The distal tip 16 and coil 18 are attached to the titanium molybdenum alloy  
22 guidewire 10 by welding or soldering. The titanium molybdenum alloy is more easily  
23 welded or soldered than NiTi alloys.

1 The guidewire 10 can be coated with a plastic for making the guidewire slipperier.

2 The guidewire can be coated with Teflon ® or a similar material for a hydrophilic  
3 coating.

4 The proximal end 12 of the guidewire 10 can have a coating or surface making it  
5 easier to grasp for the doctor to more effectively use the guidewire.

6 The guidewire 10 can be made with lengths of preferably between 20 cm and  
7 500cm and between diameters of 0.005 inches and 0.040 inches with a coil length  
8 preferably of between 0.5cm and 100cm....

*Ins 910*  
9 The guidewire 10 can have a coil made from platinum, tungsten or other similar  
10 materials for helping to make the coil radio opaque such that it shows up on imaging  
11 equipment making the guidewire easier to view while in use.

12 Obviously , many modifications and variations of the present invention are  
13 possible in light of the above teachings. It is therefore to be understood that, within the  
14 scope of the appended claims, the invention may be practiced otherwise than as  
15 specifically described.

16 What is claimed is:

1